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A Multiple-Room, Continuous Beam Delivery, Hadron-Therapy Installation

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Abstract

A proton-therapy hospital installation, based on multiple beam extraction systems from a fixed-field synchrotron, is presented and commented. Potential interest as hospital operation efficiency, as well as estimates of the impact of continuous, multiple-port extraction, on the cost of a session, are discussed.

Keywords: FFAG, spiral scaling FFAG, fixed field accelerator, medical accelerator, hadron-therapy *PACS:* 29.20.c, 29.27.a, 41.85.p

1. Introduction

Hadron-therapy nowadays is based on the use of synchrotron or cyclotron accelerators. However, potential and interest of fixed-field alternating gradient accelerators (FFAG) in this type of application, in various ways which will be recalled here, have been addressed in diverse studies (Antoine (2009), Yokoi (2005), Meyroneinc (2001)).

Based on the specificities of the FFAG technology, and using appropriate RF systems (Ohmori (2008)), the principles of a hadron-therapy treatment center that would exploit multiple, continuous extraction to several treatment rooms, can be devised (Méot (2011)) (Figs. 3 and 5). The present report addresses and discusses the various aspects and the potential advantages of the FFAG technology, compared to state-of-the-art hadron-therapy installations.

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This study and the arguments that it convenes do not intend to be understood as bringing proofs of feasibility. Neither does this study want to conclude on the trends of the method in the matter of costs. In that respect, Euro amounts discussed in section 5 are there purely as an indication and for relative cost comparisons, without any aim of rigid statements. The goal of this study is, rather, to contribute to the on-going discussions in these fields and to bring ideas which are thought to be profitable to the use of hadron-therapy as a method to fight cancer.

The FFAG method is addressed in section 3, the application of multiple-port, simultaneous extraction in a hadron-therapy center is addressed in section 4. An economical impact study is discussed in section 5.

2. State-of-the-art

The use of hadron beams for radiotherapy has been proposed in 1946 (Wilson (1946)). The technique leans on the property of the "Bragg peak", whereas the dimensioning of the accelerator (its energy) is directly related to the Bragg peak depth and the nature of the particle used (Fig. 1).

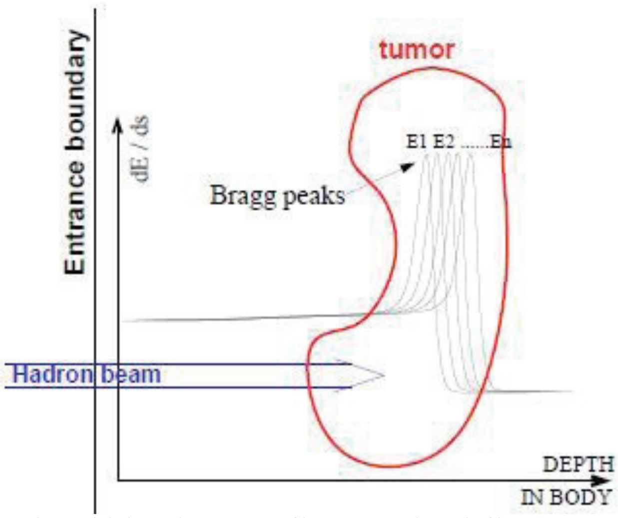

Figure 1: Bragg peak penetration. The particle beam looses most of its energy at the end of its energy range. Bragg peak penetration depth can be varied by changing the beam energy, according to the rule : depth [cm] $\approx$ $2.034 * 10^{-13}\ E[eV]^{1.7}\ A/Z^2$ (Meyroneinc (2012)).

A schematic layout of a typical proton-therapy installation is shown in Fig. 2. The accelerator (asynchrotron or, more often a cyclotron), features a single extraction beam line, which splits towards five treatment rooms further down the line. Beam delivery to the rooms is thus by nature sequential. Simultaneous extraction from more than one port, from synchrotrons* or cyclotrons†, is doable, however of reduced interest in the former technology given the limited average intensity that can be delivered, whereas the latter would have to face increased issues of extraction losses in a medical environment.

* It was envisaged in the design of Loma Linda, yet not applied due to presumed difficulty of the management of simultaneous, multiple-port beam (Coutrakon (2014)).
† Confer the ARRONAX isotope production installation based on a cyclotron with two extraction systems (Martino (2007)).